The Fire Piston

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TOOLS:

- Drill (1)
- Tap and die set (1)

PARTS:

- O-rings (2)
- Rod (1)
- Tube (1)
- Ball knob (1)
- Tee fitting (1)
  instead of the ball knob and tap and die set
- Adhesive (1)
- Petroleum jelly (1)
- Epoxy glue (1)
- Lathe (1)
- Sandpaper (1)
- Plastic polish (1)
- Steel wool (1)

SUMMARY

Carl von Linde was dead tired. The eminent engineer, considered the father of the modern refrigerator, had just returned to his home in Germany from a lecture tour that took him to,

among other places, Malaysia. This being the late 19th century, the voyage had taken months. Von Linde had seen and learned much during his excursion to Southeast Asia, and as a faculty member of the prestigious Munich Technical University, he was obligated to deliver a presentation on the results and findings of his trip to students and faculty.

During his lecture, the fatigued Herr Doktor felt the need for a nicotine hit. He paused and withdrew from his pocket a small wooden cylinder and plunger, which he called ein Feuerkoben. The small device was a gift from the people he had met on Penang Island in the Strait of Malacca. The indigenous people of the region used it to start fires. A person experienced in the use of the Feuerkoben, or fire piston, could reliably provide hot, glowing embers anytime they were needed, even under the humid conditions of the rain forest.

At the lectern, von Linde slapped the plunger down and the tinder inside ignited. He plucked out a glowing ember and lit his cigarette with it. It was a neat gesture; to the audience, it looked like he had produced fire from nothing at all — no match, no flint. The fire had magically appeared from the bottom of an empty, hollowed-out tube.

The concept was not lost on audience member Rudolf Diesel, who was one of Professor von Linde's most promising students. Diesel had been experimenting with the recently invented internal combustion engine and was growing frustrated with the spark-ignition engine's inherent low efficiency. When von Linde lit that cigarette, a question jumped into Diesel's head: Could the same thermodynamic process that ignited the tinder in the bottom of the fire piston also ignite fuel in an internal combustion engine? If so, perhaps here was a way to significantly improve the engine's efficiency. And as history proved, it was indeed.

Unlike typical gasoline engines, the eponymous and now ubiquitous diesel engine has no spark plug or carburetor. Instead, the diesel engine works by compressing fuel under very high pressures. When the fuel-air mixture in the cylinder compresses, it also gets very hot. In fact, it quickly exceeds the flash temperature of the fuel and ignites it. The compressed gas expands violently upon ignition and pushes the compressing piston away with enough force to easily turn a drivetrain.

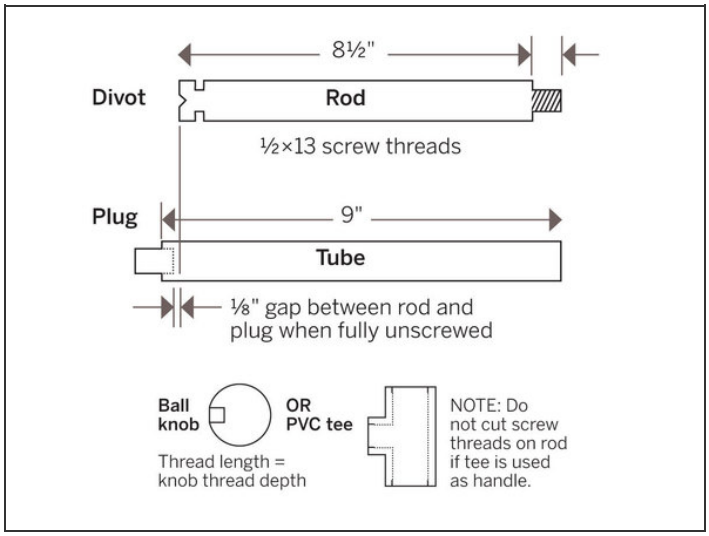
Scientists had known for 100 years that compressing a gas in a closed, insulated space causes it to get hot. In 1809, French scientist Joseph Gay-Lussac conducted experiments that proved the temperature of a fixed mass and volume of a gas is directly proportional to its pressure.

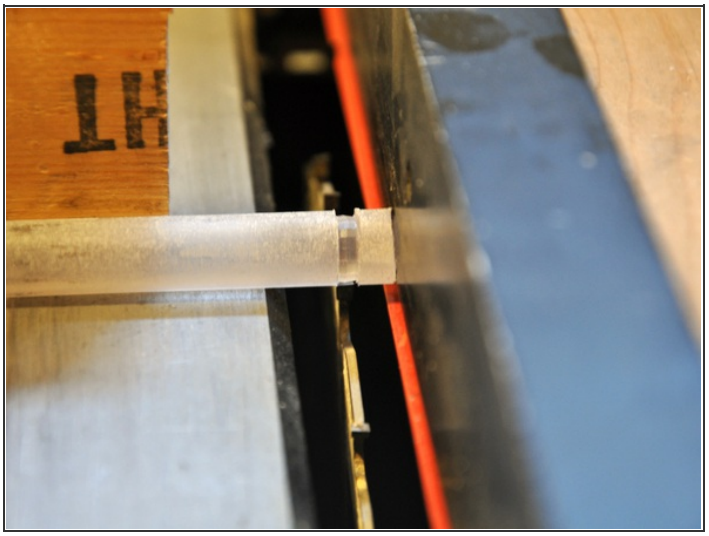
But it fell to Diesel to figure out how to use this knowledge to make a high-efficiency engine that could work with no need for a spark. Diesel published a paper in 1893 outlining his ideas

for a spark-free, compression-ignition engine. In 1897, he built the world's first working compression-ignition internal combustion engine.

Was von Linde's fire piston the true antecedent of the Mack truck engine? Well, accounts vary, but one thing is certain: the fire piston is not only fun to make and use, it's scientifically interesting and historically significant. Here's how to make your own.

Step 1 — Cut the O-ring groove.





- Referring to the assembly diagram (Figure A), cut the groove for the O-ring about ¼" from the end of the rod. The depth of the groove should be just slightly less than the width of the O-ring. If the groove is deeper, the O-ring won't seal against the tube properly. If the groove is too shallow, you won't be able to insert the rod into the tube.
- The best way to cut the groove is with a lathe. But if you don't have one, then what? Improvise! I used a table saw to cut the groove, and after a bit of trial and error, it worked fine.
- Raise the saw blade so the height of the blade protruding over the table equals the diameter of your O-ring, minus 1–2 hundredths of an inch.
- Carefully spin the rod as it contacts the blade to make an even slot. (You might not succeed on your initial tries. The rod is long enough so you can cut off mistakes and try again.)

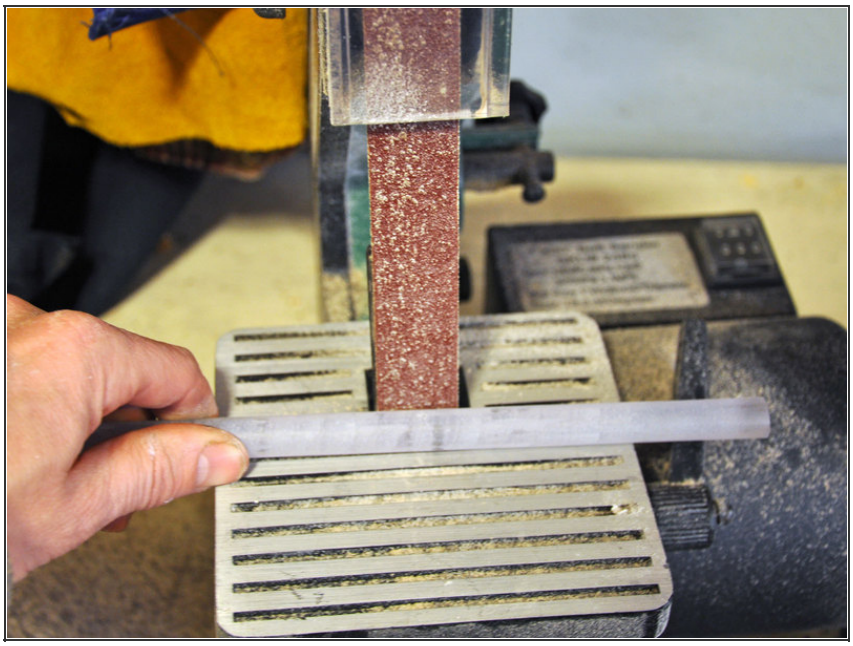
Step 2 — Glue the plug.

- Using cyanoacrylate or methylene chloride-based adhesive, glue the short rod into an open end of the tube. It's very important to make this end airtight. Glue it well, and rotate the plug in the tube to distribute the glue.

Step 3 — Install the handle.

- Use a die to cut a ½-13 thread on the other end of the rod. Screw the ball knob onto the thread. Alternatively, instead of using a ball knob, you can glue the rod into the middle hole of a ½" PVC tee fitting for a handle. If you do this, you won't need a die.

Step 4 — Fit the piston.

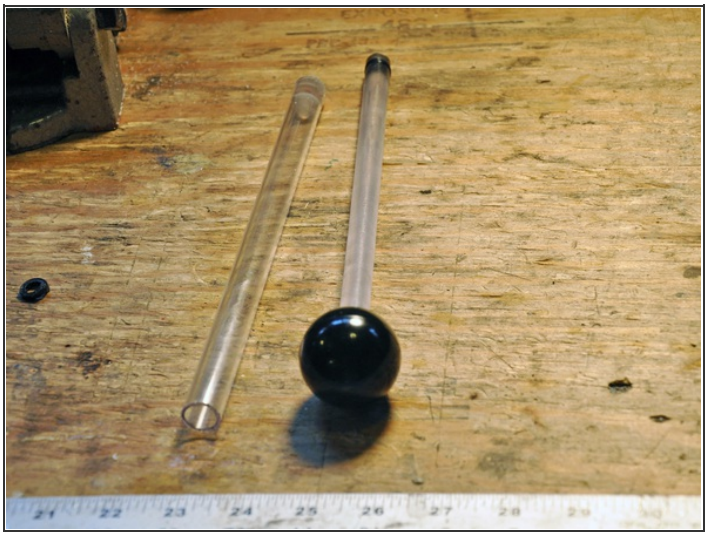


- Slide the rod into the tube and check the fit. Use a sanding belt or sandpaper, steel wool, and polish to make a close but free-sliding fit between rod and tube.
- Cut the rod to a length of about 9½", but measure it carefully first: optimally, there should be about 1/8" of space separating the end of the rod from the plug when the rod's fully inserted.

Step 5 — Install the O-ring.

- Depending on the width of the slot you cut and the shape of your O-ring, 1 or 2 rings will fit in the slot.

Step 6 — Drill the "divot."



- Drill a ¼" hole " deep, centered in the end of the rod. Your fire piston is now complete.

Step 7 — Test for air leaks.

- Smear petroleum jelly on the O-ring and carefully insert the rod into the tube, working the O-ring past the edge of the tube. Press the piston down to the bottom of the cylinder. If you've done everything correctly, the piston will smoothly and easily pop back up, nearly to the top, when you release it.
- If you press on the piston and it just stays in the tube, then the fire piston won't work. If this happens:
  - Check for leaks in the plug by spraying the end with soapy water and looking for bubbles when you compress the piston. Seal any leaks.
  - Improve the sliding fit by adjusting the depth of the O-ring groove and/or repolishing the piston.

Step 8 — Load and fire!

- Place a pinch of flammable material in the divot at the end of the rod. The best material is charcloth (see step 9).
- Smear more petroleum jelly on the O-ring, then carefully insert the piston, working the O-ring past the opening. Place the plug end of the fire piston on a hard surface.
- Quickly and firmly press down on the knob. You'll see a bright flash in the bottom of the fire piston. Carefully remove the piston from the tube and blow on the glowing charcloth in the divot.
- You can now use the smoldering ember to start a larger fire.

Step 9 — Make charcloth.

- What's charcloth? Basically, it's cotton cloth that's been roasted to blackness at high temperature but in the absence of air, the way wood is roasted to make charcoal. The wonderful thing about charcloth is that it's very easy to ignite with just a small spark. Charcloth doesn't really burst into flame easily, but it doesn't take much for it to catch fire and smolder, making it just right for starting something else on fire, like tinder or even a cigar.
- Punch a small hole in the top of an airtight metal container such as a candy tin.
- Place some 100% cotton cloth in the tin and replace the top.

Step 10

- Go outside and place the container on a handful of hot charcoal briquettes. Almost immediately, the cloth inside will start to roast, and white smoke will pour out of the hole.
- After several minutes, the smoke volume will decrease or stop, signaling that the charcloth is done.
- Remove the tin and let it cool. Once it has cooled, you can remove the top and take out the charcloth.

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